

APOLLO PROGRAM DIRECTIVE

No. 29

Post-Accident Changes to Apollo Command and
Service Module and Related Ground Facilities

July 6, 1967

Note: APD No. 29 completely
supercedes APD No. 25
dated Feb. 28, 1967.

OFFICE OF MANNED SPACE FLIGHT
PROGRAM DIRECTIVE

M-D MA 1400.064
(Project)

DATE
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APOLLO PROGRAM DIRECTIVE NO. 29

MA 009-025-1A

FROM:

[Signature]
APOLLO PROGRAM DIRECTOR

TO

SUBJECT: Post-Accident Changes to Apollo Command and Service
Module and Related Ground Facilities

ACTION: All Centers are to implement the requirements of this
directive effective with the issuance date and on a
continuing basis.

REFERENCE: 1. M-D MA 1400.061 Apollo Program Directive No. 26,
April 18, 1967, Preparation of Test and Checkout
Plans and Procedures at KSC.

I. PURPOSE

This Program Directive defines the post-accident changes
to be made in the Apollo spacecraft and ground facilities
and assigns responsibilities and schedules for making them.

II. SCOPE

This Directive covers both accident and non-accident related
changes required in the design, manufacture, test and
operation of the Apollo Command and Service Modules and
direct interfacing facilities, equipment and procedures.
This Directive in conjunction with Apollo Program Directive
26 (Reference 1) supersedes Apollo Program Directive 25.

III. RESPONSIBILITY

Primary responsibility is assigned for each change. Each
Center with primary responsibility shall arrange for parti-
cipation of the other Centers as appropriate. In this
Directive the changes which are the responsibility of MSC
are grouped together. Where such changes may lead to pro-
cedural changes at KSC this has been noted. As called out
in Reference 1, MSC is generally responsible for the require-
ments and specifications and KSC for the development of
procedures in these cases.

IV. ALTERNATE ACTIONS

If, during the course of complying with the action directed
herein, an additional or alternate action is considered
appropriate in the interest of feasibility or improved
safety or performance, such action shall be submitted to
the Apollo Program Director for review.

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V. MSC ACTIONS REQUIRED--ACCIDENT RELATED

All accident related changes shall be made on the first Block II spacecraft,

A. MATERIALS

1. Materials Selection--Non-metallic

- a. Non-metallic materials selection criteria, approved by the Spacecraft Program Manager, shall be implemented to minimize flammability and toxicity hazards.
- b. Non-metallic materials shall be selected for the Block II spacecraft using guidelines approved by the Spacecraft Program Manager, as adequate, and consistent with the approved criteria. Departures from these guidelines shall be approved by the Spacecraft Program Manager and submitted immediately to the Apollo Program Director for information.
- c. A final list of all non-metallic materials for each Block II spacecraft, along with appropriate supporting data including the location, amount, and application of the material shall be approved by the Spacecraft Program Manager and submitted for information to the Apollo Program Director two weeks prior to each Customer Acceptance Review.
- d. Final selection of non-metallic materials shall be based on test results, both sample testing and, for cabin non-metallic materials, full-scale boilerplate flammability tests. The test results shall be reviewed and approved by the Spacecraft Program Manager and submitted as a part of the background data with the final materials list in (c) above.

2. Materials Selection--Metallic

A final list of any metallic materials which could potentially contribute to the flammability or toxicity hazards shall be approved by the Spacecraft Program Manager and submitted for information to the Apollo Program Director two weeks prior to each Customer Acceptance Review.

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3. Space Suit Materials Selection

The selection of materials for use in a new Block II space suit configuration shall follow the same general procedures as for other materials. Specifically, the Spacecraft Program Manager shall be responsible for approving the new configuration and submitting it, plus appropriate supporting data, to the Apollo Program Director for his information at the conclusion of the Critical Design Review. Changes in suit materials shall require the approval of the Spacecraft Program Manager.

4. Materials Control

Requirements shall be documented for controlling the materials used in the design of the Block II spacecraft and for controlling the introduction of both flight and non-flight materials into the cabin during manufacture and test. Procedures to implement these requirements at NAA and MSC shall be developed by MSC; KSC shall implement procedures in accordance with Reference 1. The MSC procedures shall be approved by the Spacecraft Program Manager and submitted to the Apollo Program Director for his information by July 15, 1967.

5. Materials Placement and Stowage

- a. Materials shall be placed in the spacecraft in a manner designed to inhibit fire ignition and to inhibit fire propagation.
- b. Potentially flammable materials in the cabin for manned testing or flight shall be stowed in fire-resistant containers. Cabin stowage requirements shall be such as to minimize the exposure of potentially flammable materials during all mission phases including pre-launch ground testing. The Spacecraft Program Manager shall approve the Block II cabin stowage and cabin materials handling requirements and submit descriptive data to the Apollo Program Director for his information two weeks prior to each spacecraft Customer Acceptance Review. Procedures to implement these requirements at NAA and MSC shall be developed by MSC; KSC shall implement procedures in accordance with Reference 1.

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6. Cleaning Materials

Requirements shall be documented for selecting cleaning fluids and solvents and for limiting, controlling and recording the use in the cabin of those which may be flammable or have flammable or conductive residues. Requirements shall also be documented for removing undesirable residues and for testing to assure that hazardous residues have been properly removed. Procedures to implement the requirements at NAA and MSC shall be prepared by MSC; KSC shall implement the requirements in accordance with Reference 1. Information copies of these procedures shall be sent to the Apollo Program Director by July 15, 1967.

B. EMERGENCY EGRESS

1. Command Module Side Hatch

- a. A quick-operating, outward-opening unified side hatch shall be provided for the CM.
- b. The hatch release mechanism shall be manually operable in less than five seconds from either inside or outside independent of pressure differentials.
- c. A means, not requiring assistance from the inside, shall be provided to open the hatch, once released during ground testing.
- d. Operation of the hatch from outside the CM, in space or on the ground, shall be possible without personnel injury or damage to the spacecraft.
- e. Adequate safeguards against inadvertent operation shall be implemented to protect flight and ground crews.
- f. The new side hatch shall be ground tested on SC 004, 2S-2, 007A, 2TV-1, and 2AV-1.
- g. The hatch flight test configurations on SC 017/SA-501 and SC 020/SA-502 shall be such that either flight in conjunction with ground test data will provide sufficient test data to verify the hatch design for manned flight.

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2. KSC Facilities Interface

- a. MSC shall provide a CM mock-up to KSC for egress training. The delivery date and configuration description shall be provided to KSC and the Apollo Program Director by July 15, 1967.
- b. MSC shall assist KSC in defining the interface requirements between the CM unified side hatch and the Access Arm at the Launch Complex.
- c. MSC shall assist KSC in defining the interface within the KSC vacuum chamber to assure rapid emergency egress.

3. MSC and NAA Facilities

Necessary changes in design and procedures shall be implemented to provide effective emergency crew egress during tests, e.g., in vacuum chambers, at MSC and NAA before the resumption of manned testing.

C. FIRE EXTINGUISHMENT

1. A crew operated, portable fire extinguisher shall be provided in the CM.
2. Crew procedures for fire extinguishment shall be developed and demonstrated.
3. A report on the fire extinguisher, including test results and crew procedures, shall be submitted to the Apollo Program Director prior to the first manned Block II spacecraft test.

D. MATERIALS TESTING

1. Sample Tests

Sample tests of materials shall continue, as necessary, to support the materials selection program.

Test procedures shall be standardized and documented with an information copy to the Apollo Program Director by July 15, 1967.

2. Full-scale Boilerplate Command Module Flammability Tests

- a. Successful completion of full-scale boilerplate flammability tests with the proper cabin atmosphere are required as part of the final confirmation of the selection of non-metallic materials for the cabin,
- b. Tests shall include a realistic simulation of actual cabin materials in placement and amount and shall be done with cabin atmospheres appropriate to the several mission phases including pre-launch ground tests.
- c. Care shall be taken in cabin simulation, ignition source simulation, data collection (including toxicity samples) and overall test procedures to ensure a meaningful interpretation and comparison of results.
- d. A detailed test plan and schedule shall be submitted to the Apollo Program Director for review by July 15, 1967.

3. Acceleration Tests

The effect of acceleration on the fire hazard in the CM shall be determined. Data applicable to the high acceleration periods during abort with the Launch Escape System, during boost, and during reentry shall be collected and evaluated. Zero-g tests shall be continued as necessary. A detailed test plan and schedule shall be submitted to the Apollo Program Director for review by July 15, 1967.

E. CABIN ATMOSPHERE

1. In Space and at Reentry

A cabin atmosphere of 5 psia, 100% O₂ will be continued in the space environment.

2. Pre-launch and Launch

- a. The capability to use 100% oxygen on the pad prior to and during launch shall be retained. An optional capability shall be provided to enable the use of conditioned air, with a

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controlled oxygen content as required, in the cabin for pre-launch and launch in case an adequate level of safety with a 100% oxygen atmosphere cannot be assured. A safe means shall be provided to exchange the air for a pure oxygen cabin atmosphere after launch. The pressure suits shall contain pure oxygen regardless of cabin atmosphere and adequate sensors shall be provided to ensure proper oxygen supply in the suit.

- b. An analysis of the operations necessary to convert from the pre-launch and launch cabin atmosphere to the in-space atmosphere shall be documented with particular attention to the crew timeline. An assessment of risk associated with the use of air in the cabin shall be documented also. This analysis shall include the possibility of suit loop failure during pre-planned abort modes as well as normal mission phases. These analyses shall be submitted to the Apollo Program Director for review by July 31, 1967.
- c. A detailed test plan to demonstrate the air option shall be submitted to the Apollo Program Director for review by July 31, 1967.

F. ELECTRICAL SYSTEM

1. Cabling Protection--Electrical

- a. Criteria for protection of the Block II spacecraft wiring based on the prevention of overloaded wires shall be developed and implemented.
- b. Circuit protection devices based on the criteria for Block II wire shall be inspected as installed and compared with installed wiring prior to manned testing. The results of this inspection shall be included in the Block II spacecraft Customer Acceptance Review documentation.

2. Cabling Protection--Mechanical

Electrical cabling shall be protected from damage during fabrication, installation, testing and flight.

- a. Sharp corners and protrusions that could damage wires on harness jigs and mockups shall be eliminated.

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- b. Harnesses shall be protected from sharp edges and protrusions in the spacecraft.
 - c. Protective covers with insulated coatings shall be provided immediately after installation of wiring.
 - d. Wire terminations on connectors, circuit breakers and batteries shall be adequately spaced and insulated.
3. Inspection and Fabrication
- a. Wire for use in the spacecraft shall be inspected to ensure conductor continuity and insulation integrity (along the entire length of each wire).
 - b. Means of stripping insulation and other operations which might damage the installed wire shall be evaluated and revised as necessary.
 - c. The configuration of the three-dimensional jig shall be reevaluated to conform as nearly as possible to the actual spacecraft configuration. Particular attention shall be given to connector and cable clamp orientation.
 - d. Inspection of wiring after modifications and at preset intervals in the spacecraft preparation period shall be mandatory.
4. All non-hermetically sealed electric current switching devices in the cabin (e.g., circuit breakers and motor switches) shall be investigated to ensure that none are ignition sources in the appropriate oxygen cabin atmosphere. This investigation shall be conducted and documented with an information copy to the Apollo Program Director two weeks prior to the first Block II spacecraft Customer Acceptance Review.
5. Procedures shall be implemented by MSC to insure that future design and implementation changes or waivers are examined to preclude the introduction of potential ignition sources into the spacecraft.
6. Wiring of redundant systems shall be separately cabled and routed where practicable.

7. Requirements for powering down the spacecraft in emergencies shall be developed. Procedures to implement these requirements at NAA, MSC and in flight shall be developed by MSC. KSC shall implement procedures in accordance with Reference 1. These MSC requirements and procedures shall be documented and an information copy submitted to the Apollo Program Director prior to the first Block II spacecraft Customer Acceptance Review.

G. ENVIRONMENTAL CONTROL SYSTEM

1. Atmosphere Control System

- a. Aluminum oxygen lines in the cabin which contain solder joints shall be replaced with steel lines with brazed or welded joints.
- b. Additional surge capacity shall be provided to shorten cabin repressurization time.
- c. An additional valve shall be provided in the new unified hatch to shorten the cabin depressurization time. This valve shall be operable from the inside or outside and shall be protected against inadvertent operation.
- d. Emergency breathing masks shall be provided for individual crew members.

2. Thermal Control System

- a. The present inhibited water glycol shall be retained.
- b. The following changes shall be made to reduce coolant system leaks;
 - (1) Voishan washers and improved tightening procedures shall be applied to all mechanical fittings.
 - (2) Quick disconnects with self-sealing check valves shall be added to facilitate maintenance without spilling coolant.

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- (3) Solder joints shall be eliminated where possible by combining line lengths or by brazing.
 - (4) Solder joints subject to abuse shall be protected with armor.
 - (5) Stress relief between solder joints and mechanical fittings shall be ensured.
 - (6) Means of assuring that solder joints are properly made and that there exist no unacceptable residual stresses on joints shall be implemented.
 - (7) Protective covers shall be provided for all exposed plumbing lines in the cabin during installation, test and flight.
- c. Adequate requirements for cleaning up leaked or spilled coolant without leaving a harmful residue in the cabin shall be developed. MSC shall implement these requirements at MSC and NAA; KSC shall implement the requirements in accordance with Reference 1.
 - d. Requirements for testing to ensure that any harmful residue in the cabin has been satisfactorily removed shall be developed. MSC shall implement these requirements at MSC and NAA; KSC shall implement the requirements in accordance with Reference 1.
 - e. Records of all coolant leaks and spills, the areas affected (especially electrical cables), and the remedial action shall be included in the spacecraft documentation available at the Customer Acceptance Review. Requirements for continuing these records until launch including submissions at the FRR shall be developed by MSC and implemented by KSC in accordance with Reference 1. MSC shall implement similar procedures for testing at MSC.

H. VIBRATION TESTING

1. Vibration/acoustic tests of a Block II spacecraft shall be conducted at the Manned Spacecraft Center with the objectives of:

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- a. Verifying vibration levels at subsystem locations,
- b. Verifying mechanical interconnections (including wiring) in the vibration environment.
- c. Verifying structural integrity of the hatch.
2. The test configuration shall be a basic Block II spacecraft:
 - a. Flight plumbing and connections.
 - b. Tanks and plumbing under pressure.
 - c. Flight cabling and connections,
 - d. New plumbing and cabling protection.
 - e. Actual subsystems or equivalent mass simulations.
 - f. Vibration instrumentation.
3. The test plan shall be based on:
 - a. Sine sweep vibration.
 - b. Wiring continuity checks before and after.
 - c. Leak checks before and after.
4. The test plan shall be designed to achieve the test objectives with minimum risk of destruction of the spacecraft. The reuse of this spacecraft for flight is an objective.
5. The need to operate electrical systems and ECS during the vibration tests shall be examined.
6. The test plan with supporting rationale, description of the spacecraft configuration and an assessment of risk to the spacecraft shall be submitted for approval to the Apollo Program Director by July 15, 1967.
7. These tests shall be satisfactorily completed prior to the first manned flight.

I. EMERGENCY EQUIPMENT

The requirements for emergency equipment in test areas at NAA and MSC shall be reviewed. Additional necessary

emergency equipment shall be provided and those responsible for its use trained in its operation. Procedures shall be implemented for reexamination of these requirements as changes in procedures or configuration make it necessary.

VI. MSC ACTIONS REQUIRED--NON-ACCIDENT RELATED

A. BLOCK II COMMAND AND SERVICE MODULE CHANGES

The following non-accident related changes shall be made on the first Block II spacecraft.

1. Hydrogen shall be purged from the water tank to eliminate the quantity gauge as a possible ignition source.
2. The following ECS control changes shall be made to facilitate emergency operation:
 - a. Suit circuit return valve - add permanent handle on flexible extension available to crew.
 - b. Suit Demand Regulator - add permanent handle.
 - c. Direct O₂ metering valve - use stowed handle, add valve position indicator.
 - d. Main regulator selector - add permanent handle.
 - e. O₂ shutoff valve - disconnect or eliminate valve.
 - f. Emergency inflow valve selector - add permanent handle.
 - g. Primary radiator circuit by-pass valve - add permanent handle and flexible extension.
 - h. Cabin pressure relief valve - tilt the valve mounting panel.
3. Use the onboard TV camera for crew monitoring during pre-launch test and checkout operations.

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4. Provide for water chlorination.
5. Provide a manual, mechanical lock to prevent inadvertent operation of the postlanding vent valves.
6. Provide for the automatic connection of the entry batteries to main power buses at abort initiation.
7. Improve pushbutton and toggle switch guards to prevent inadvertent operation.
8. Relocate the center couch J-box to prevent wire damage.
9. Modify the time delay of the reaction control system rapid dump timers to improve pad abort capability on the Up-rated Saturn I launch vehicle.
10. Provide a single mode recovery light to enhance recovery operations.
11. Rigidize the hand controller mounts.
12. Replace the hand controller 1.7 sec timer with a 3 sec timer to improve CSM/Adapter separation.
13. Redesign stowage and fasteners; include quick disconnects on stowage containers.
14. Improve crew couches to facilitate egress and crew operations.
15. Prevent inverter motor lockout.
16. Add SM RCS helium line check valve filters.
17. Modify the Pre-Modulation Processor (PMP) circuit breaker to provide redundant power to the S-band system.
18. Add the following instrumentation:
 - a. 10 sequential events discrete outputs.
 - b. 1 glycol temperature control cabin monitor.
 - c. 10 ECS flight performance measurements.
 - d. 3 EPS radiator inlet temperatures (if fuel cell outlet temperature sensors are not provided).
 - e. 3 linear accelerometers.

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19. Add SM RCS coarse, integral, thruster filters,
20. Add CSM RCS relief valve port covers.
21. Provide for entry battery C backup to either battery bus,
22. Improve the data storage equipment tape motion flag indicators,
23. Provide for postlanding vent valve direct air flow to the crew,

B. SPACECRAFT 2TV-1 CONFIGURATION

Changes in addition to those approved for 101 and changes approved for 101 but not planned on 2TV-1 shall be identified and submitted to the Apollo Program Director for review by July 15, 1967,

C. CONFIGURATION INFORMATION

A summary of changes in the CSM and LM and their effectivity approved by the Level II Configuration Control Board shall be submitted to the Apollo Program Director. The submissions shall follow the CCB action by not more than one week,

VII. KSC ACTIONS REQUIRED--ACCIDENT RELATED

All changes shall be made on Launch Complex 34 to support the first manned flight. Proposed detailed schedules for implementation of all changes on both LC 34 and LC 37 and the KSC Industrial Area shall be submitted to the Apollo Program Director by July 15, 1967. LC 39 shall be reviewed in light of the Apollo 204 accident and any necessary changes submitted to the Apollo Program Director for review by August 15, 1967.

A. EMERGENCY EGRESS

1. The Launch Umbilical Tower and Access Arm shall be modified to improve emergency egress:
 - a. Modify the adapter hood to accommodate the new CM hatch.
 - b. Modify the mechanism and provide an intermediate park position to shorten the reposition time of the Access Arm.

- c. Eliminate steps and protrusions in the egress path which could hinder rapid emergency egress.
 - d. Provide bi-directional swinging doors for the Access Arm.
 - e. Provide for positive ventilation for the Access Arm Environmental Chamber.
 - f. Provide additional lighting in the Access Arm Environmental Chamber to illuminate the CM hatch.
 - g. Provide redundant power for lighting in the Access Arm Environmental Chamber.
 - h. Provide fire resistant materials in the Access Arm Environmental Chamber.
2. Vacuum Chamber Area: Necessary changes in design and procedures shall be implemented to provide effective emergency egress during tests in KSC vacuum chambers before the resumption of manned testing.
3. Training Facilities: KSC shall provide a mockup of the CM Access Arm to mate with the CM mockup which is to be supplied by MSC for egress training.
- B. LAUNCH COMPLEX EMERGENCY EQUIPMENT
- Adequate provisions shall be made for emergencies including:
- a. Installing a ground override capability on the number 4 elevator.
 - b. Adding permanent explosion-proof lighting to the spacecraft GSE area at the base of the Service Structure.

- c. Installing additional warning lights and audible devices,
- d. Providing additional gas masks, protective clothing and emergency tools,
- e. Providing additional exhaust fans.

These provisions shall be reexamined as changes in procedures or configuration make it necessary, and personnel shall be trained in their use.

C. ON-BOARD TV MONITORING

Provisions shall be made for monitoring and recording crew operations inside the CM during hazardous tests using the on-board TV camera,

D. GROUND COMMUNICATIONS

- 1. The following procedural changes shall be made:

- a. Minimum requirements for access to the system shall be defined and continuing access control procedures shall be established.
- b. The configuration and operational readiness of the communications system shall be inspected and verified by test before each major space vehicle test.
- c. Throughout all major space vehicle tests, communication systems engineers with knowledge of the entire voice system shall be on duty.
- d. Continuous recordings of critical voice communication loops shall be obtained during major tests.
- e. A comprehensive method of documenting and controlling the configuration of the inter-communication system shall be implemented.
- f. Operating characteristics shall be reviewed with personnel prior to their use of the system.

- 2. The following equipment changes shall be made:

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- a. Modify the astronaut communication consoles in the Launch Complexes to eliminate the undesired coupling between the voice communication links and to provide full duplex communication to the spacecraft over the umbilical cable without the use of voice operated (VOX) devices.
- b. Delete the locking feature on all push-to-talk microphones and remove loud speakers where feasible.
- c. Provide for the modification of the input to the Operational Intercommunication System from the unified S-Band (USB) station on Merritt Island so that the proper voice signal levels and noise levels are maintained.
- d. Provide headset elements with improved frequency response and increased efficiency.
- e. Provide additional central testing facilities at KSC to permit continuous circuit quality monitoring.
- f. Minimize the use of voice operated (VOX) devices in the Operational Intercommunications System.
- g. Augment the present ground Operational Intercommunications System with 4-wire full duplex stations, utilizing the present cable plant where possible, to interconnect the spacecraft, blockhouse, spacecraft checkout station, and the Houston Mission Control Center. The following loops were 4-wire before the AS-204 accident and will remain so:
 1. Flight Director.
 2. Mission Director.
 3. Air Ground No. 1.
 4. Air Ground No. 2.
 5. Recovery Coordination.
 6. Public Information Officer.

The launch critical loops are to be made 4-wire before manned flight, including:

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1. Launch Operations Manager.
2. Spacecraft Test Conductor.
3. Aero Med.
4. Spacecraft System Monitor X.
5. Launch Vehicle System Monitor X.
6. Launch Vehicle Test Conductor.

E. PROCEDURES

Procedural changes shall be made (Reference 1) as required based on MSC changes called out in Section V of this Directive.